WATER

HYDROLOGICAL DATA

NO. 7

GROUND-WATER RECONNAISSANCE

OF

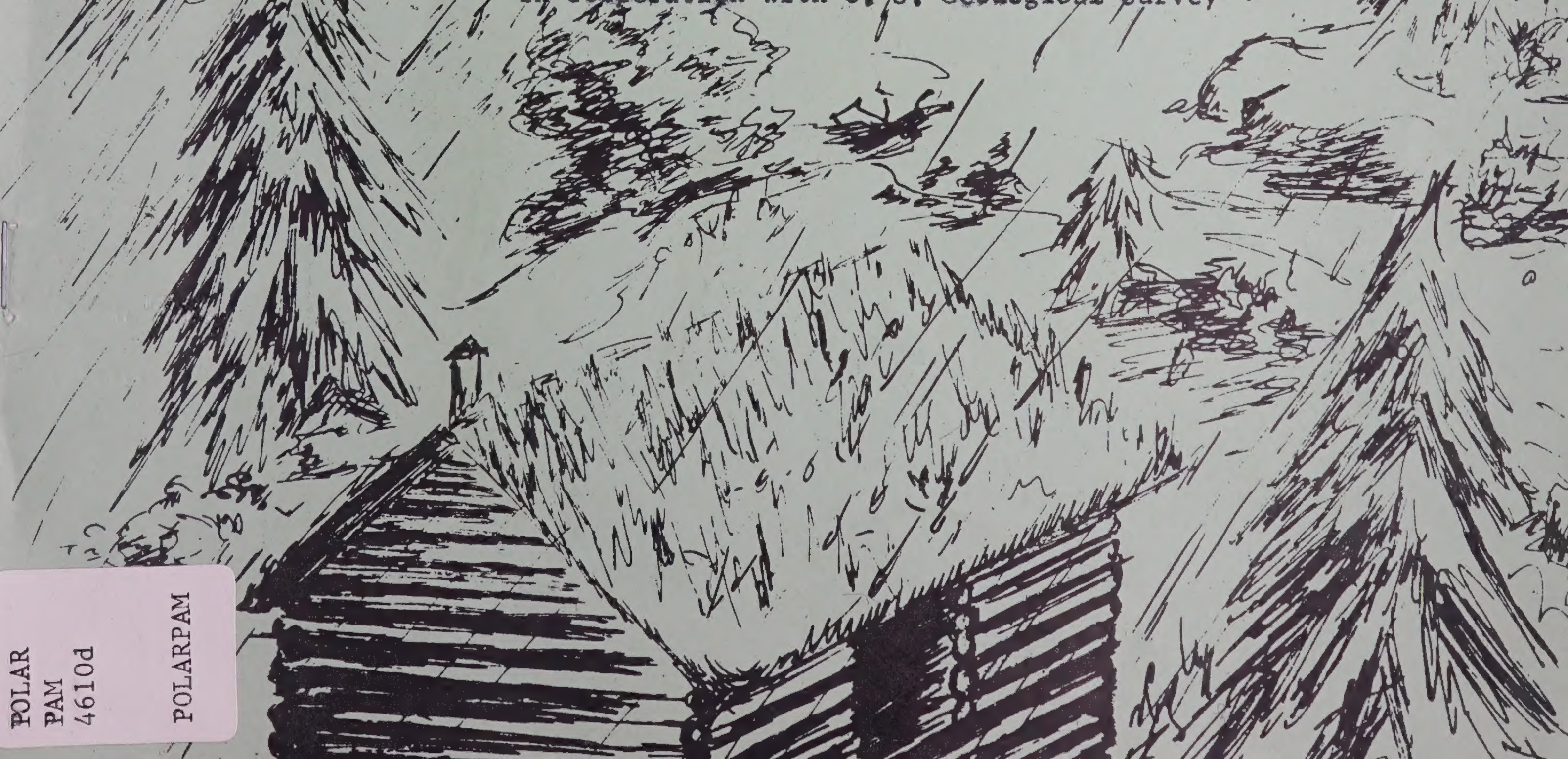
KOYUK AND SHAKTOLIK VILLAGES, ALASKA

ALASKA DEPT. OF HEALTH

SECTION OF SANITATION & ENGINEERING

JUNEAU - ALASKA

In cooperation with U. S. Geological Survey



GROUND-WATER RECONNAISSANCE

OF

KOYUK AND SHAKTOLIK VILLAGES, ALASKA

By

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Prepared in cooperation with the Alaska Department of Health

Open-File Report

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INTRODUCTION

This is the fourth in a series of brief open-file reports on ground-water investigations in Eskimo villages in Alaska. The first, released in September 1955, described ground-water conditions at five villages in the lower Kuskokwim-Yukon River area. The second, released in April 1957, covered six villages in the Kobuk-Noatak area. The third, released in July 1958, covered the two villages on St. Lawrence Island. The studies are being made by the U. S. Geological Survey under the auspices of the Alaska Department of Health as part of its sanitation-aid program in the Eskimo villages. The investigations in these villages add to the general program of the Geological Survey in evaluating the ground-water resources of Alaska.

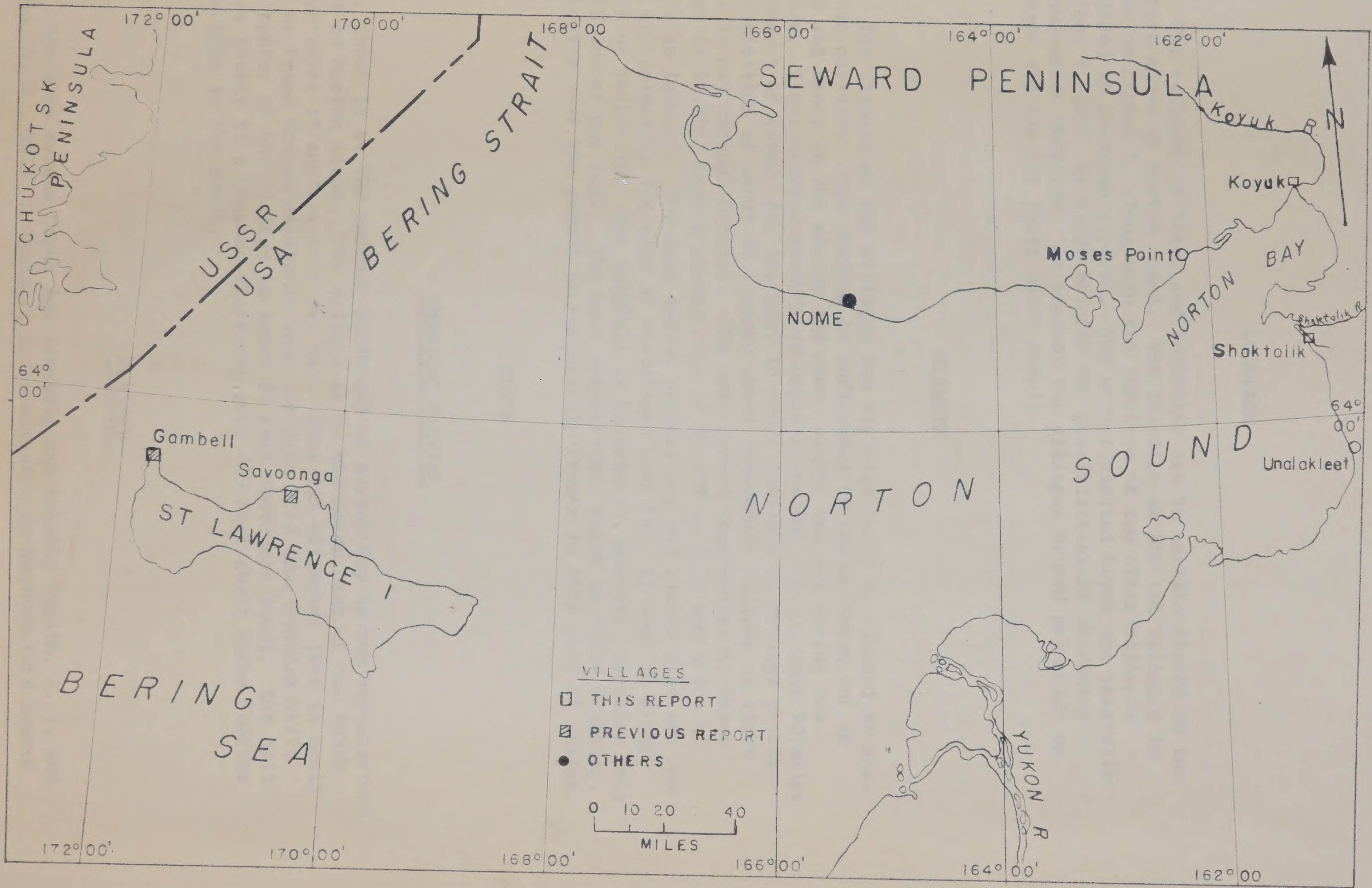

Figure 1-- Map of a part of Alaska showing location of Koyuk and Shaktolik

LOCATION

The villages of Koyuk and Shaktolik are in western Alaska on the eastern shore of Norton Sound. The location of the two villages is shown on figure 1, along with the location of two other villages included in previous reports. The writer visited Koyuk and Shaktolik on June 7, 1957, to study briefly the possibilities of obtaining ground-water supplies. At present the villages depend primarily on streams and ice for their water supply.

CLIMATE

The climate of the villages and vicinity could be classed as sub-arctic maritime. The weather is influenced by Norton Sound and is cold and windy in the winter and cool, windy, and wet during the summer. Precipitation records at Moses Point (see fig.1), some 30 miles southwest of Koyuk, for the past 12 years indicate an average yearly precipitation of about 19 inches, about two-thirds falling as light rain in May through October. The mean annual temperature at Moses Point is 24.2°F, with a record high of 57.4°F in July and a low of -13°F in January. The mean annual temperature and record high and low are approximately the same at Unalakleet (see fig. 1) some 30 miles south of Shaktolik. The rainfall at Unalakleet, however, averages only 12.42 inches per year. The mean temperature, which is below freezing, indicates that the ground is perennially frozen in this part of Alaska.

KOYUK

Physical Setting

Koyuk is at the extreme north end of Norton Bay in the northeastern part of Norton Sound. The village is on the north bank of the Kobuk River where it empties into the bay. Some 125 villagers live in small log or frame houses clustered near the base of a low, rounded hill. The center of the village ia about 30 feet above sea level. The hill rises gently to a maximum elevation over 400 feet about three fourths of a mile to the north.

Geology

The area around Koyuk was investigated briefly (Smith, P. S. and Eakin, H. M., 1911, A Geologic Reconnaissance in Southeastern Seward

Peninsula and the Norton Bay-Nulato Region, Alaska: U. S. Geol. Survey Bull. 449) for the purpose of compiling a geologic map and report. G. C. Martin and others (1919, Report of Progress of Investigations in 1917, Mineral Resources of Alaska: U. S. Geol. Survey Bull. 692, p.384) discussed briefly the occurrence of coal seams about a mile east of the village and their possible economic use. Their findings are summarized on page 7 of this report.

The bedrock composing the hill at Koyuk was described (Smith and Eakin, p. 110) as consisting of "black limy schist and limestone" beds striking approximately north and having nearly vertical dips. No outcrops are present within the village, but this writer noted many angular quartz, limestone, and chert fragments on the village beach. The angular character indicates that the material has not been transported far. Frost action is evident on the hillslopes, where bedrock fragments have been worked loose and are slowly migrating downslope.

Gray clay is exposed at an elevation of about 30 feet, underlying what appears to be a stream-or-wave-formed terrace or bench extending through the village. A similar terrace is present up the slope (north) of the village at about 100-foot elevation. A new airstrip has been constructed on the upper terrace by means of grading and leveling the surficial unconsolidated material. Limestone bedrock was encountered in a few places. The terrace deposits are probably marine or alluvial sediments which were laid down after rock terraces were cut by wave or stream action. Bedrock may be some tens of feet below the surface of the lower terrace, as compared to its shallow depth beneath the upper terrace.

Permafrost

Permafrost can be expected in this area because Koyuk lies near the north edge of the discontinuous-permafrost zone (Hopkins, D. M., Karlstrom, Thor N. V., and Others, 1955, Permafrost and Ground Water in Alaska: U. S. Geol. Survey Prof. Paper 264-F, p. 116), where perennially frozen ground is present except under speical conditions. Permafrost was noted on the upper terrace just north of the village where the ground was cleared for the airstrip. Its presence caused construction difficulties, so the strip was shifted to the northeast where thawed ground was present. It is likely that the presence of thawed ground near the surface was due to good subsurface drainage in coarse-grained sediments. Furthermore, permafrost usually is not present near the surface on the southerly slopes of hills in the discontinuous-permafrost region. The thickness of permafrost is unknown but is expected to be several hundred feet. For comparison, it is reported (Smith and Eakin, p. 110) that a shaft was sunk on Alameda Creek, about 10 miles north of Koyuk, in frozen

gravel to a depth of 192 feet, where water was encountered in such force that the miners had to abandon the shaft. Permafrost was not noted or reported within the village of Koyuk, but it probably occurs there also.

Water

Koyuk is conspicuous for the ground-water seepage that occurs within the village. A lush growth of grass and bushes and thousands of mosquitoes attest to the abundance of moisture at this locale. It is reported that the ground is almost continuously wet in an area near the east side of the village. Seepages were noted also along the shoreline. A "spring" occurs about a quarter of a mile west of the village. The villagers report that a small hole was dug (about 3 feet) here because a seep was noticed. The water was flowing at an estimated rate of 1 or 2 gallons per minute and the temperature of the water was 32.5°F on June 7, 1957. An analysis (see p.10) indicates that the water is chemically satisfactory, although it has a little color. Some of the villagers use the spring, but it is a little too far away from the village for convenience. It is not known if the spring flows during the winter, but the near-freezing temperature suggests that the flow probably stops in cold weather.

Another seepage area was excavated about 300 feet north of the school for a school supply. This location is on the hill slope above the upper terrace. The shallow excavation produced water but soon "silted up" and was abandoned. The numerous other seeps within the village proper have not been exploited, mainly because the water may be polluted.

A small stream drains a small lake on the lower ground just east of the village. The water was flowing at a rate of perhaps 10 gallons per minute and the temperature of the water was 59°F on June 7, 1957. The water is highly colored but is still used as a water supply during the summer and as an ice supply during the winter.

Conclusions

It seems probable that ground water is available at shallow depths at Koyuk. A dug, jetted, or driven well should obtain water within the unconsolidated material (soil and loose rocks) near the surface. Well attempts would probably be most successful upslope from the major seepage area and near the foot of the slope from the upper terrace. Dug wells would be more susceptible to surface pollution, so care should be taken in selecting a site and constructing such a well. The fine-grained material near the surface might tend to plug the screen of a driven well; nevertheless, the ease of constructing a driven well may make an attempt

worth while. Thought might be given also to the possibility of installing a horizontal drain in the slope above the seepage area, by tunneling, driving a well point, or other means. The bedrock probably contains water in fractures and thawed zones, but a drilling rig would be required to drill into the consolidated rock.

Coal Deposits

The presence of coal in the vicinity of Koyuk is discussed briefly here at the request of Territorial agencies in their interest in providing a more stable economy in the native villages.

Martin (1919, p. 384) states: "Lignite is obtainable in the Candle district**** Coal of a generally similar character is found near the mouth of the Koyuk, just about at sea level, where one 4-foot seam is said to be exposed. Near by is a 2-foot seam, and several seams of a few inches in width also occur." Martin states further: "The locality on the Koyuk was not visited, but it is said to be near or at tidewater, and some difficulty might be had at times in mining on account of flooding the workings*** If the deposit is workable, it should furnish a fuel at least as good as wood***" An analysis of the coal is as follows:

	Percent
Fixed carbon	39.87
Volatile combustible	33.94
Moisture	19.94
Ash	5.86
Sulfur	.44
	100.00

This writer can add little to the above because a proposed visit to the coal prospect was not made. Present Koyuk villagers know very little about the coal because the exposures are not as evident now as they must have been at the time of Martin's work. It would appear that the prospect might be explored to determine if coal could be produced for local consumption, especially as the price of fuel oil runs fairly high.

SHAKTOLIK

Physical Setting

The small village of Shaktolik is on the south shore of a low, wide, flat peninsula (part of a coastal plain) which connects the prominent Cape Denbigh and the Reindeer Hills to the mainland (fig. 1).

A small stream parallels the shoreline for several miles in the vicinity of the village; thus, Shaktolik is situated on a long, narrow (500 ft.) strip of land. The stream enters Norton Sound about 4 miles to the west, near the mouth of the Shaktolik River. Tidal fluctuations of about 2 feet are noticeable in the stream at the village. The maximum elevation of the ground at the village is about 30 feet above sea level.

Geology

The surface deposits at Shaktolik are gray sand and gravel which extend to a depth of at least 10 feet. The only known subsurface data for the coastal plain area was obtained from a prospect hole (Smith and Eakin, p.78) about 20 miles north near the Ungalik River, which reportedly was dug nearly 100 feet without striking bedrock.

The gray to black gravel at Shaktolik is predominantly slate and is very platy. The sand is composed of quartz grains. The material was probably derived from the hills on the mainland and transported by streams to the sea. Here the material was reworked by wave action to form the long, narrow strip of land (barrier bar) across a former lagoon or mouth of the streams.

Permafrost

Although Shaktolik is within the zone of discontinuous permafrost, there is no evidence of permafrost within the village. The proximity of the ocean and the stream, and the coarseness of the surface material, probably explain the absence of frozen ground near the surface. The stream had a temperature of 55°F on June 7, 1957, and it reportedly remains open along its northern (inland) bank during the winter. The coarse surface material allows rapid drainage; hence, there is less chance of permanent freezing. Permafrost is probably present at depth in finer grained material where ground-water movement was sluggish prior to freezing. The aforementioned deep prospect hole at Ungalik was presumably in frozen ground, inasmuch as the hole was dug without encountering water.

Ground Water

Ground water is known to be present at Shaktolik. Although the rainfall is slight, the surface material is such that water from rainfall, snowmelt, and streams can percolate readily into the ground. The stream at the village is approximately 10 feet higher than the ocean;

hence, water can seep through the ground directly to the sea unless an impermeable barrier, such as permafrost, exists beneath the village. As stated earlier, permafrost probably occurs at depth. Therefore, barring the presence of other impermeable layers, ground water should occur at shallow depths and be under water-table conditions.

The proximity of this area to the sea and the low elevation of the peninsula create a situation susceptible to salt-water contamination of the ground water. Fresh water tends to float upon salt water because it is lighter. Presumably such a situation exists at Shaktolik, where the subsurface material was deposited in sea water and fresh water from streams or precipitation has necessarily had to "override" the salt water to continue its journey to the sea. The low relief of the area, however, precluded the "flushing out" to extensive depths of the original sea water.

The salt-water fresh-water interface fluctuates according to the thickness of the fresh-water "lens." Generally, for every foot of fresh water above sea level there will be about 40 feet of fresh water below sea level. A surplus of fresh water would push the interface down; conversely, a deficit in fresh-water recharge would reduce the thickness of the fresh-water layer and cause the interface to rise. The fresh-water layer undoubtedly thickens landward and gradually "wedges out" at the shoreline.

Water Supply

About 18 years ago a well was constructed for the school at Shaktolik. It is a small diameter driven well, reportedly 19 feet deep, and encountered "salty and milky" water. A hand pump was installed, but apparently the well was never used because of the quality of the water. About 1956, an inquisitive new teacher pumped the well and the water tasted good. Subsequently, an electric pump was installed and the well is now used during the school year. Reports indicate that the well gets "salty" only when strong September storms from the southwest back up the tidewater in the stream. A sample of the water (pumped 2 weeks previously) was taken for analysis. (See table on page 10.) The chloride content of 38 parts per million (ppm) is far below the Public Health Service's suggested limit of 250 ppm. It should be noted that the iron content is slightly over the desirable limit of 0.3 ppm. More reliable samples should be taken to confirm the iron content and also to keep tab on the chloride content.

It is believed that the water-table fluctuations (seasonal, tidal, and caused by variable streamflow) are appreciable and cause the fresh-water salt-water interface to fluctuate. Consequently, water drawn from

near the interface could have higher chloride content. A lowering of the water table by pumping also would induce the movement of salt water toward the well from below or from the sea.

Another school well was constructed recently about 60 feet from the creek and 160 feet north of the school and the old well. The new well was dug to 8 feet and then a well point was driven to a greater depth. Satisfactory water was obtained but the pipeline (buried 3 feet) to the school froze the first winter. No one seems to know why the pipeline was not buried deeper. The installation was subsequently dismantled, but possibly there was something wrong with the rest of the installation also.

Conclusions

The writer believes that potable ground water can be obtained with relative ease at Shaktolik. The critical problem that may be encountered is the presence of salt water at depth or by its subsequent intrusion as a result of natural or man-made causes.

The north (stream) side of the village offers sites that are: close to a shallow source of possible fresh-water recharge, farthest from the ocean and, as to surface pollution, the cleanest part of the village.

It appears that a driven or combination dug and driven well is the most economical type. Little difficulty should be encountered in penetrating the loose sand and gravel with a well point.

Since the fresh water is very likely to occur under water-table conditions, floating on salt water, extreme care should be taken not to drive a well point too far into the water-bearing zone. Thus, in effect, a producing well would only "skim off" the uppermost part of the fresh-water layer. Such a method would not permit a well of large capacity, but it would tend to eliminate the danger of pumping salt water from below the fresh water.

An ideal installation under the above conditions would be some form of horizontal intake within the fresh-water layer. A pit or trench would have to be dug to the water table and, perhaps, one or several well points driven horizontally and connected to a vertical pipe extending to the surface. The pit would then be backfilled and the immediate area protected from pollution. Such an installation would create a well whose intake would be dispersed over a larger area that that of a single vertical well point. Hence, the horizontal intake installation would reduce the lowering of the water table and the possible encroachment of salt water.

The maximum depth of safe penetration of the water-bearing zone could

probably be determined by arranging to measure the water-level fluctuations in the school well and the height of fresh-water head above sea level. The range of fluctuations would give an idea as to the maximum depth to which a well point or a horizontal "gallery" should be installed.

It is realized that the backing up of storm tidewaters in the stream allows salt water to percolate into the water-bearing zone temporarily. Hence, wells should be pumped very little, if at all, at such time, to eliminate extensive and prolonged contamination. After the storm tides recede, the fresh-water stream should gradually "flush out" the salt water in the ground. The area at the east (up-stream) end of the village would be farthest from the tidal action and thus would probably be least subject to temporary salt-water contamination.

It appears that more specific information should be obtained about the existing school well. A few water-level measurements and chloride analyses would provide a more reliable "picture" of the factors that affect the water bearing zone at the village. If the analyses show that the well is frequently salty, the well point may extend too deeply into the fresh-water wedge; hence, water is pumped from the underlying salt-water zone when the water table is low. In conclusion, the writer believes that, with due consideration of the hydrologic limitations of the fresh water at this coastal location, a supply of potable water can be obtained at Shaktolik.

CHEMICAL ANALYSES

(Chemical constituents in parts per million)

	KOYUK Spring	SHAKTOLIK Well
Date of Collection	6-7-57	6-7-57
Silica (SiO_2)	6.6	3.9
Manganese (Mn)	.00	.03
Iron (Fe)	.00	.44
Calcium (Ca)	47	3.2
Magnesium (Mg)	16	6.6
Sodium (Na)	2.6	68
Potassium (K)	.6	5.3
Bicarbonate (HCO_3)	216	144
Carbonate (CO_3)	0	0
Sulfate (SO_4)	6.0	11
Chloride (CL)	3.0	38
Fluoride (F)	.00	.00
Nitrate (NO_3)	.03	.2
Dissolved solids	188	208
Hardness as $CaCO_3$	183	35
Noncarbonate	6	0
Specific conductance (micromhos at 25°C)	350	370
pH	8.2	7.7
Color	10	0
Temperature (°F)	32.5	?